Water 2021 WEBINARS

Climate Change and Water Resources: Evidence, Impacts, Adaptation

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MDPI WEBINARS

Facing the water availability challenge in Southern Europe: What options do we have?

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POLITÉCNICA

water

MDPI

Introduction

- **Runoff vs water availability**
  - A working definition of water availability
  - WAAPA model
- **Projections of water availability**
  - Analysis of projections determining water availability
  - Global for Europe and specific for Southern Europe
- **Role of adaptation**
  - Effect of policy on water availability

Water availability

- **Runoff is a proxy for changes in water availability**
  - Water availability is frequently assumed to change as mean annual runoff does
- **In water-scarce regions, water availability is determined by infrastructure**
  - Flow regulation in reservoirs provides water availability
  - Reservoir storage theory: storage-reliability-yield relationships
- **And there are other factors…**
  - Not only changes in mean value, changes in variability are also important
  - Water management: demand type, reliability, environmental flows, priorities …

Working definition of water availability

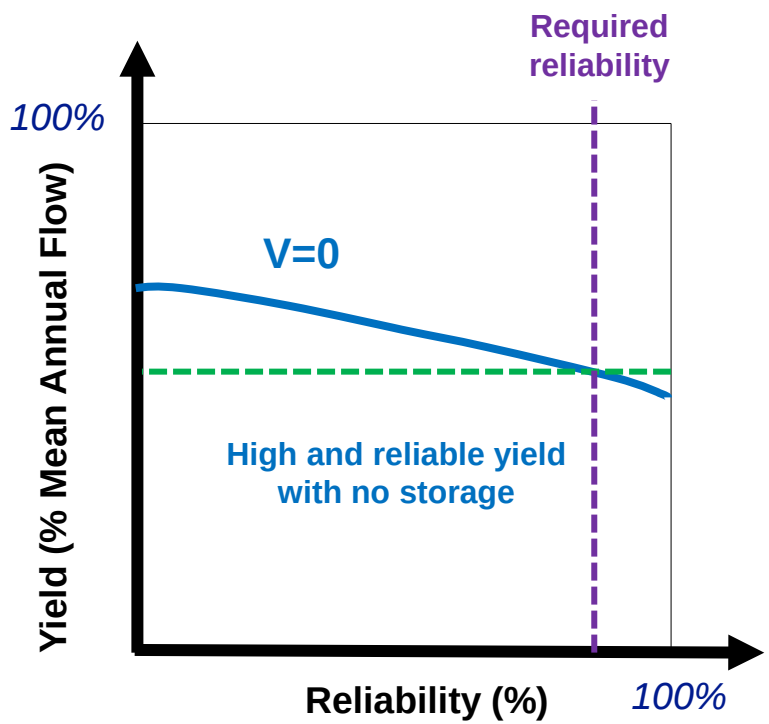
Potential “**blue**” water availability is:

- The maximum **demand** that could be supplied
- at a given **point** in the river network (abstraction point)
- using available **storage** (with evaporation)
- with realistic **management**
- respecting **environmental** flows
- with proper **monthly distribution** (urban, irrigation,..)
- satisfying adopted **reliability criteria** (gross volume reliability, maximum acceptable deficit, …)

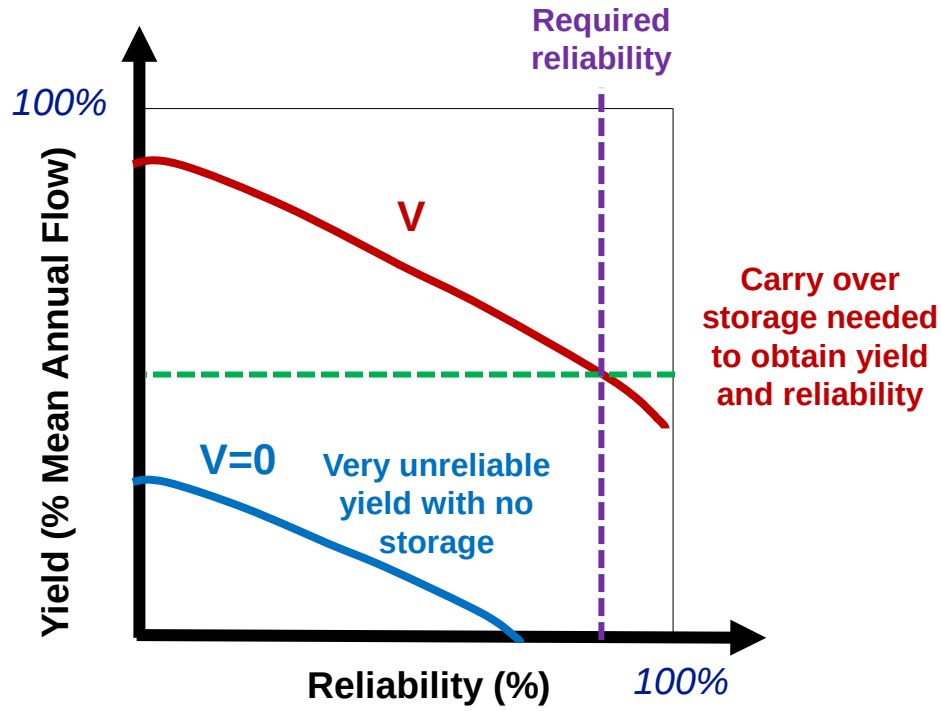
This may lead to very different results: assumptions are important

Yield vs variability

YIELD-RELIABILITY CURVE



Demand

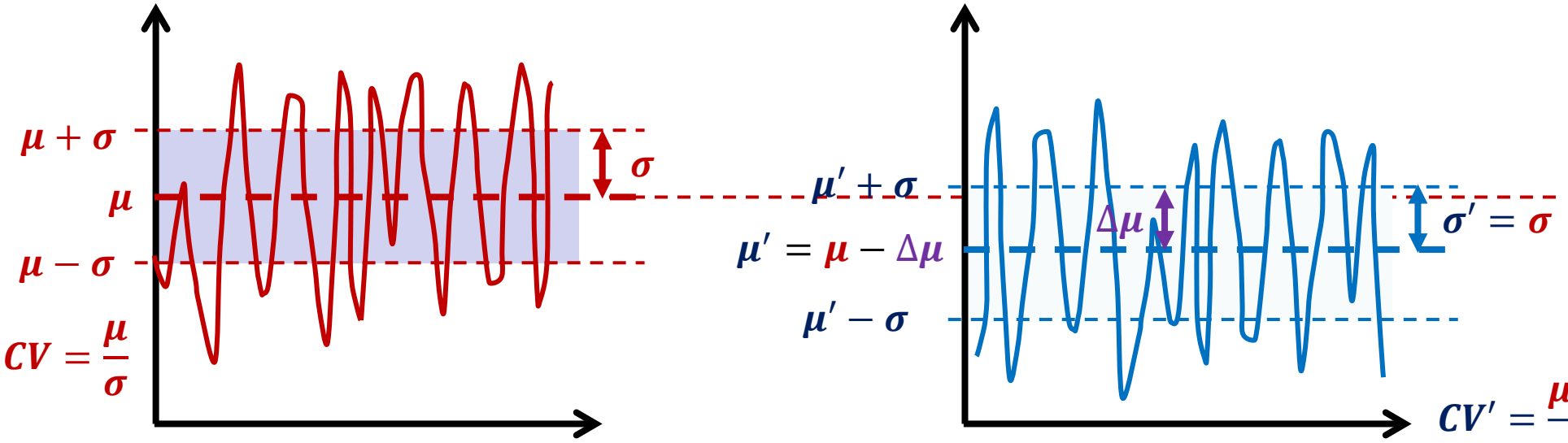


LOW HYDROLOGIC VARIABILITY
Demand can be supplied without storage

HIGH HYDROLOGIC VARIABILITY
Storage is required to supply demand

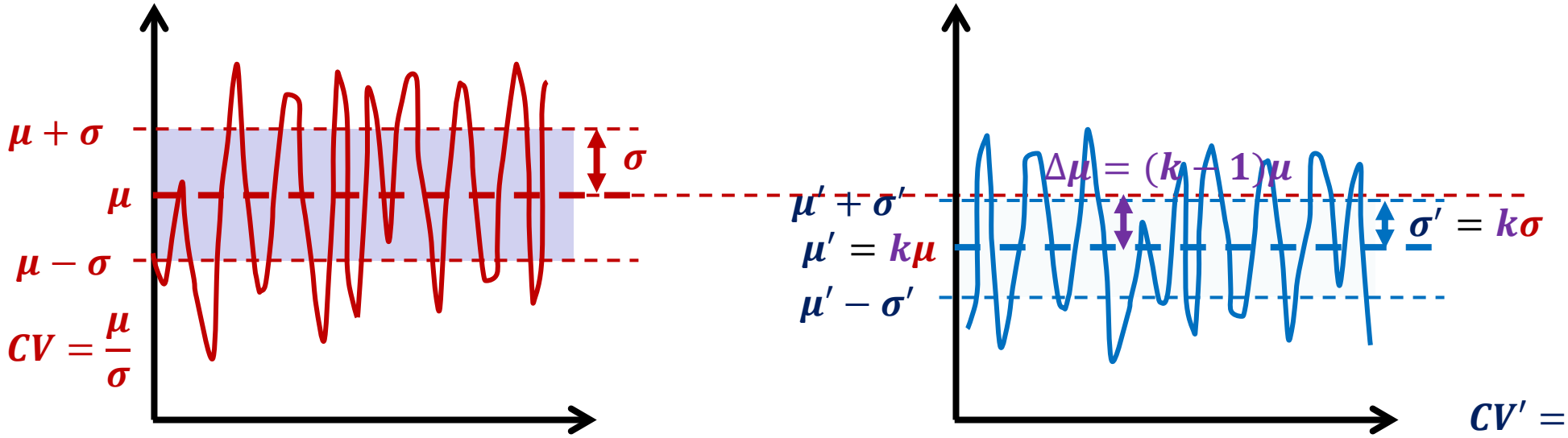
Variability is important to determine availability

The nature of change: validity of the “delta” method



Step change

Same standard deviation
Greater coefficient of variation



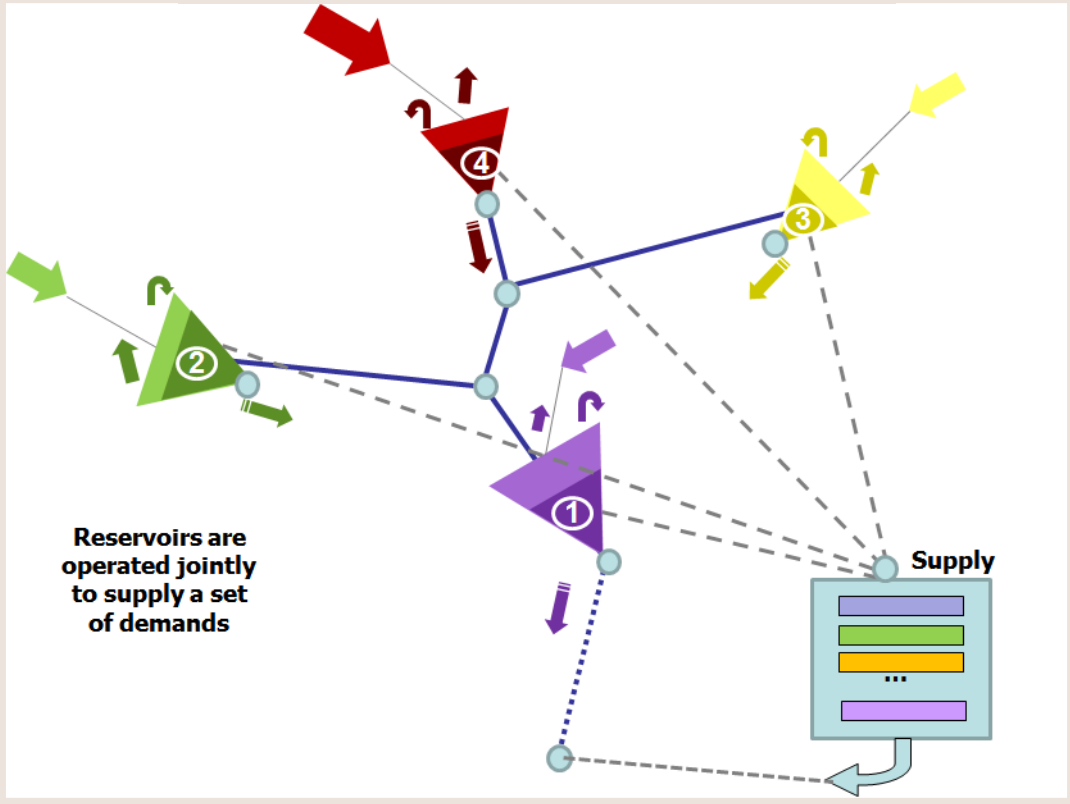
Proportional change

Smaller standard deviation
Same coefficient of variation

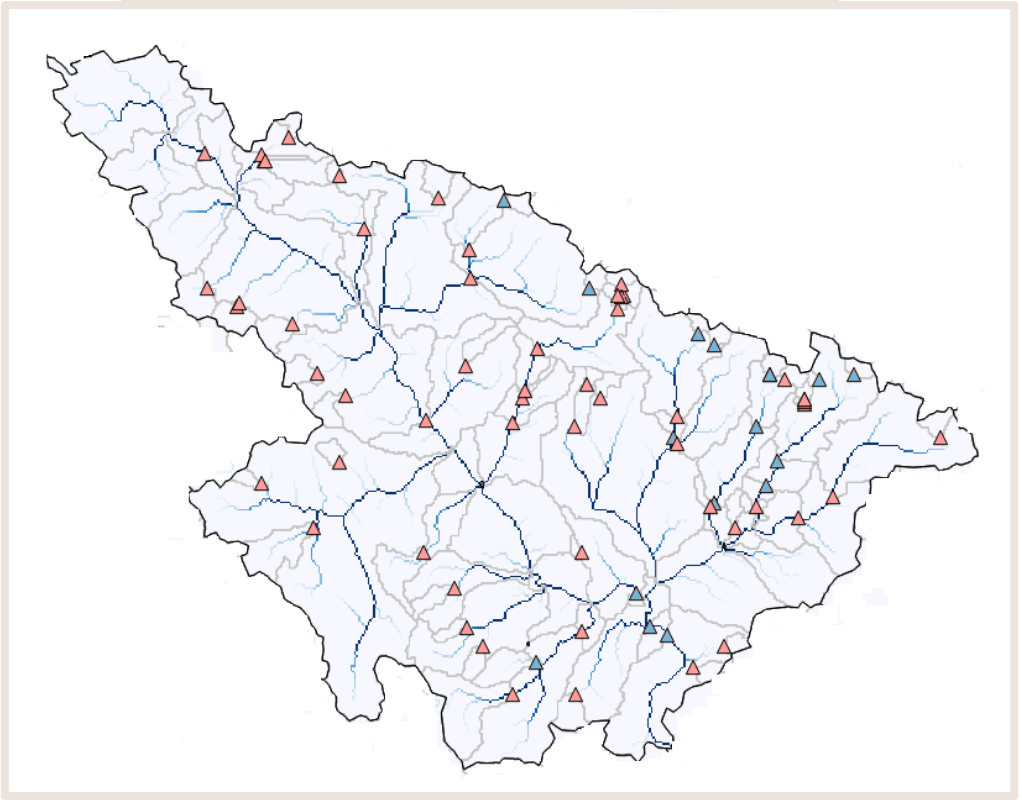
WAAPA : Water Availability and Adaptation Policy Analysis

Specifically developed to obtain water availability

WAAPA MODEL ALGORITHM

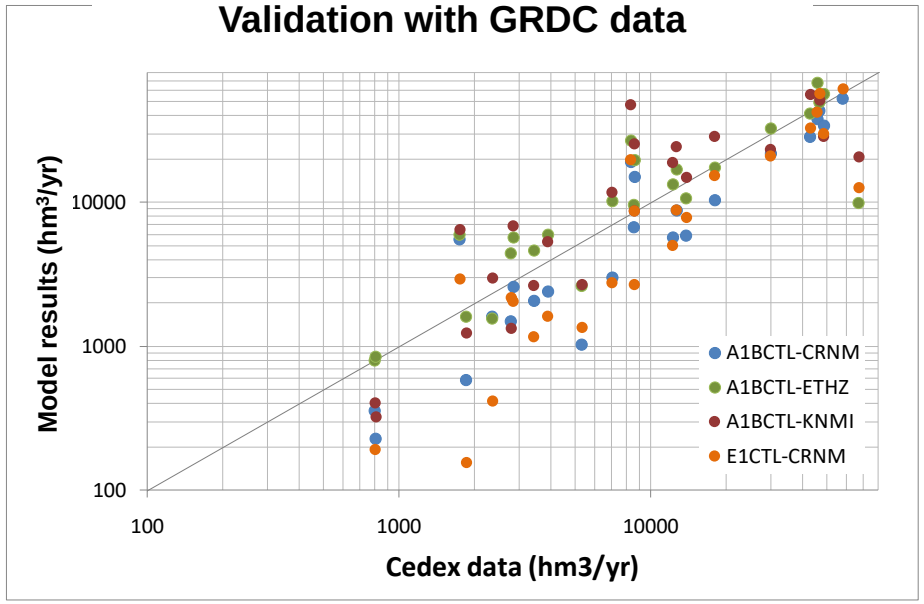


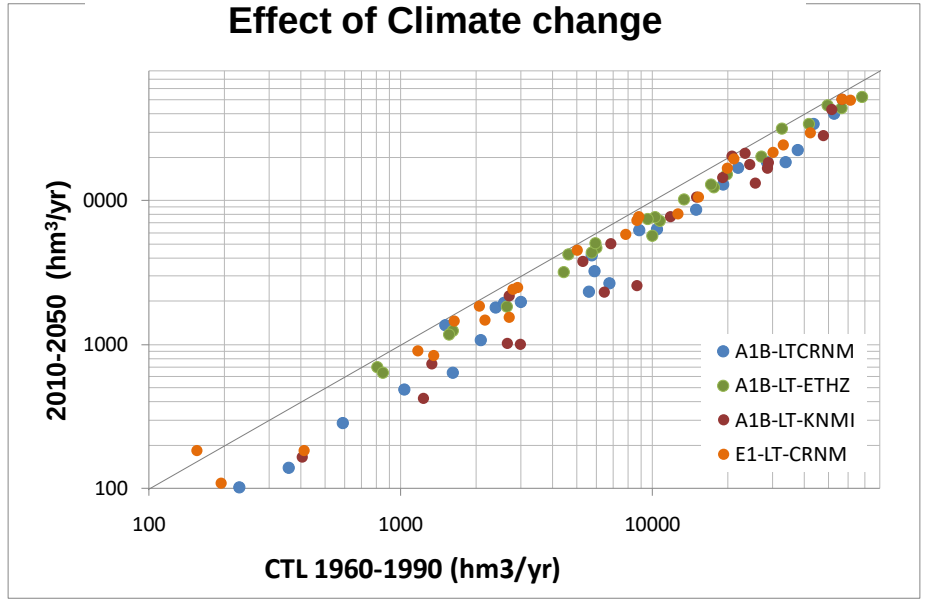
WAAPA GEOGRAPHICAL DATA



Climate scenarios

- Climate scenarios were taken from regional models in different projects: PRUDENCE, ENSEMBLES and CORDEX
  - **SRES**: 8 **A2**, 4 **B2**, 3 **A1B**
  - **RCP**: 5 **RCP2.6**, 5 **RCP4.5**, 5 **RCP6.0**, 5 **RCP8.5**
  - Time slices CTL: **1960-2000** FUTURE: **2070-2100**





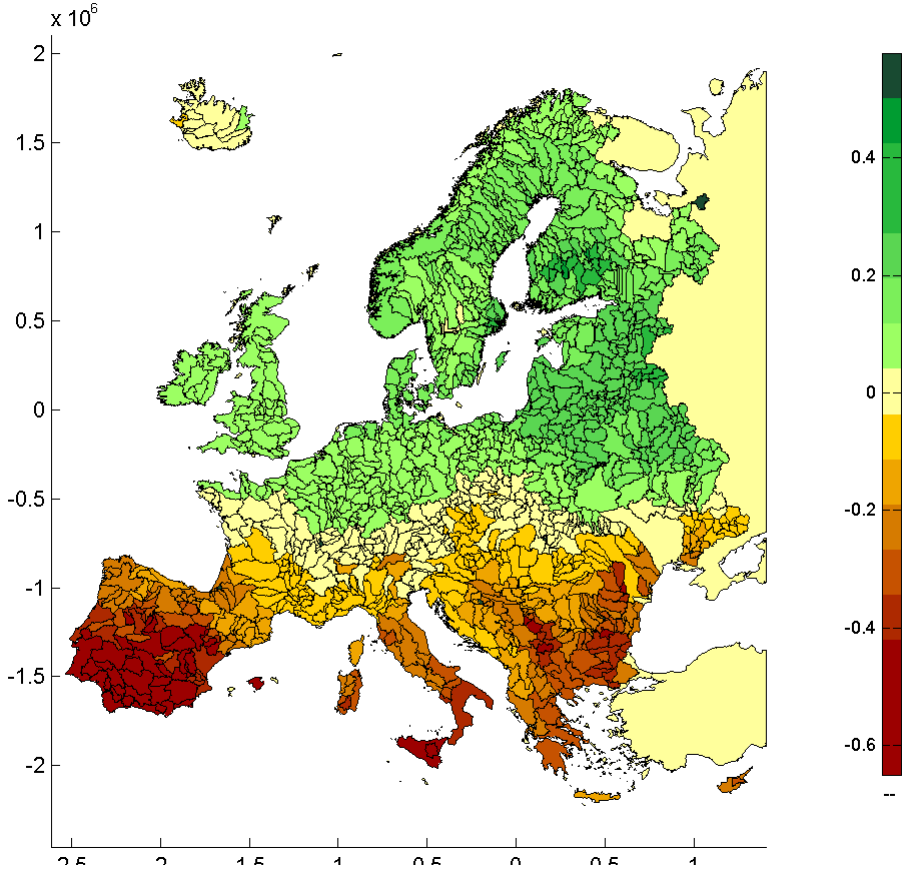
Streamflow data were corrected for **bias**

Significant **reduction** in most basins

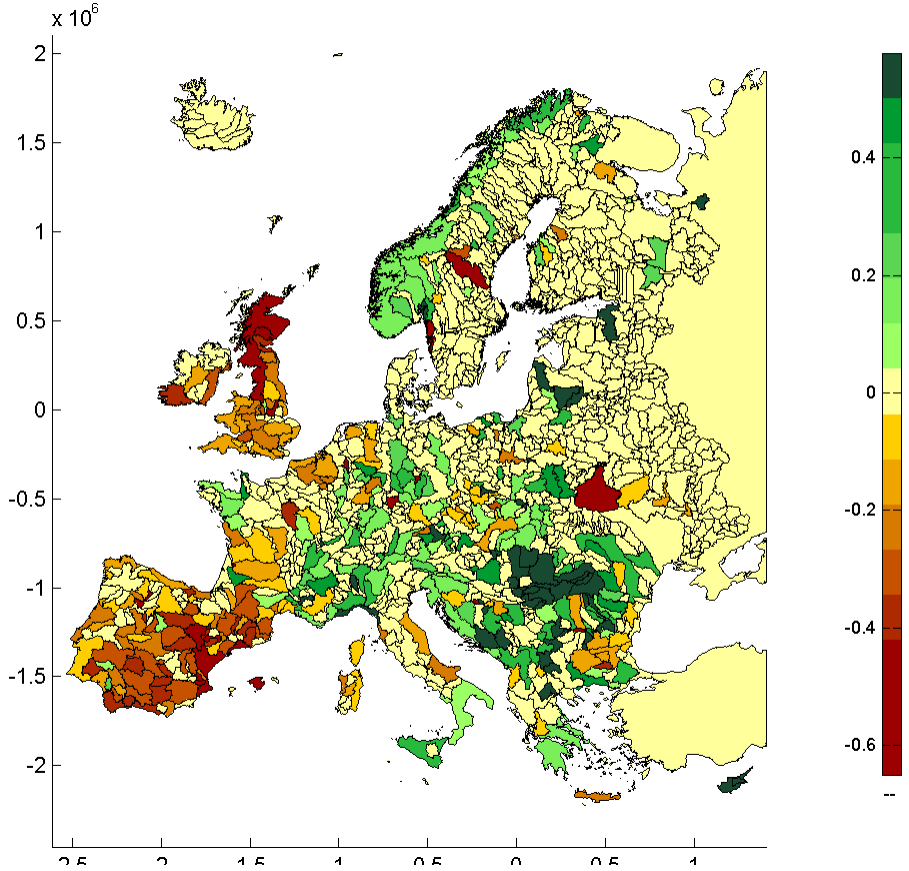
Analysis of European basins

Scenario RCP4.5

CHANGE in RUNOFF



CHANGE in LOCAL AVAILABILITY

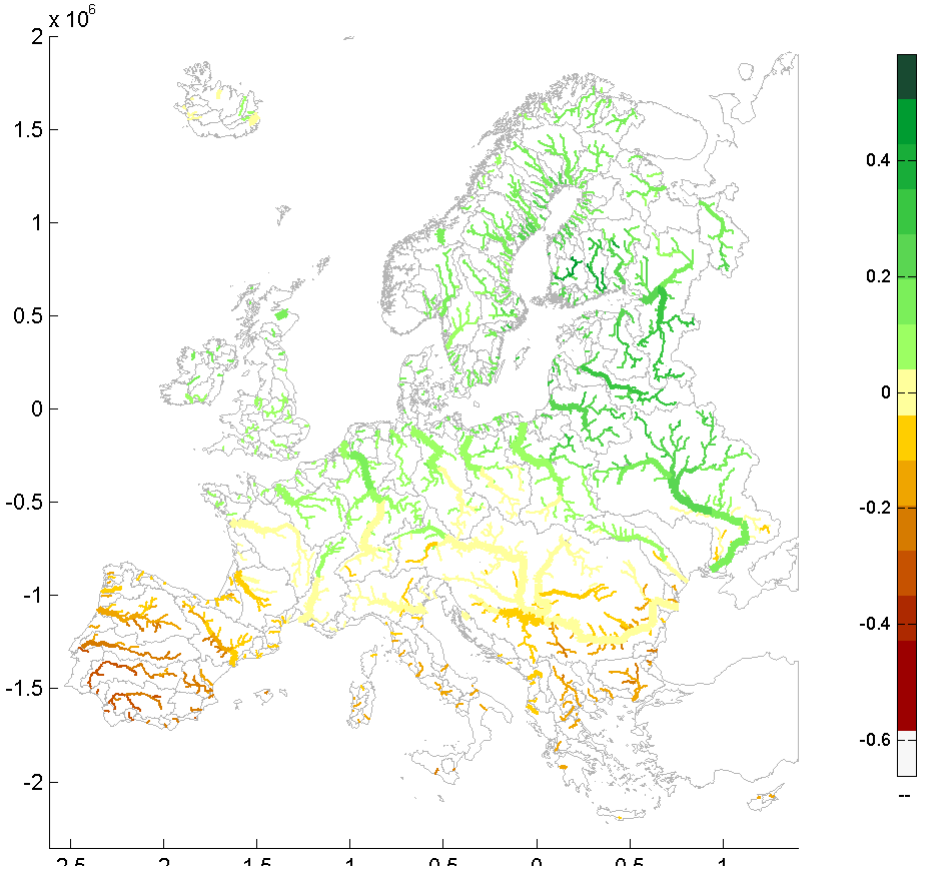


Loop over 5 models

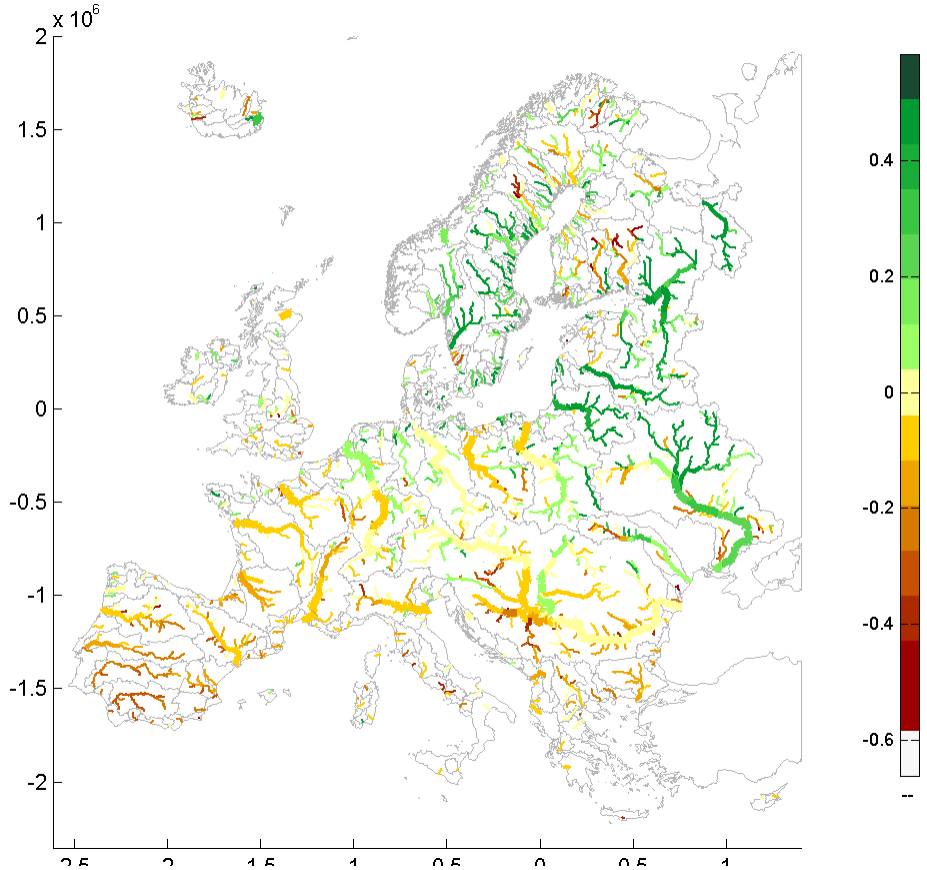
Analysis of European rivers: model uncertainty

Scenario RCP4.5

CHANGE in RUNOFF

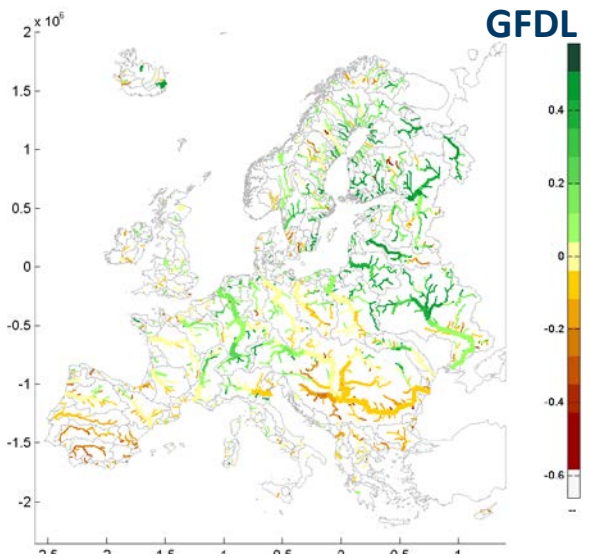


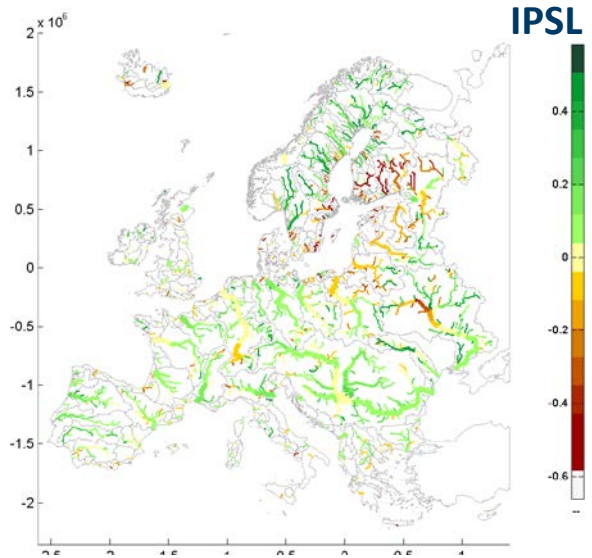
CHANGE in RIVER AVAILABILITY



Loop over 5 models

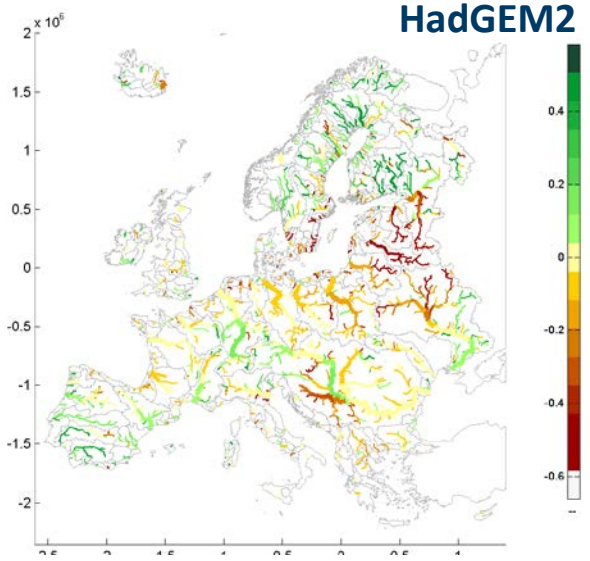
Analysis of European rivers: scenario uncertainty

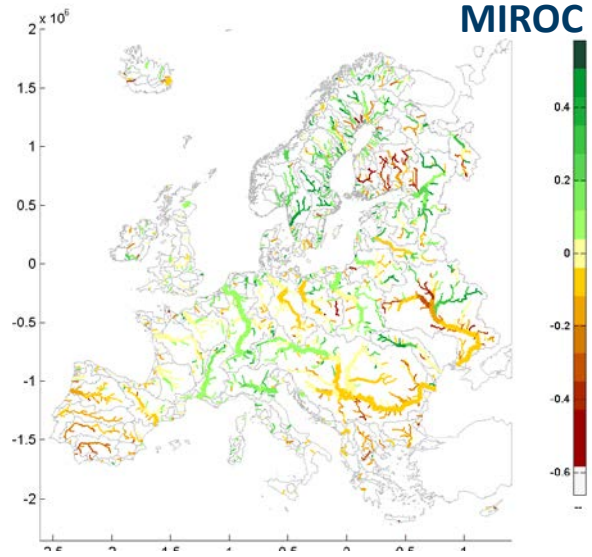


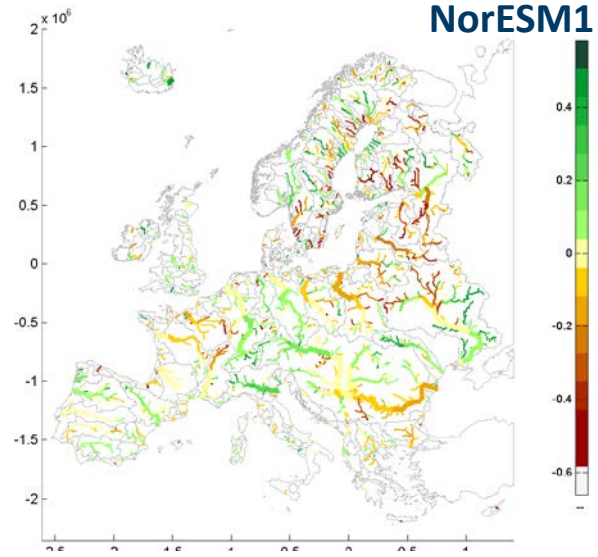


Availability in 2060-99 as a fraction of availability 1960-99

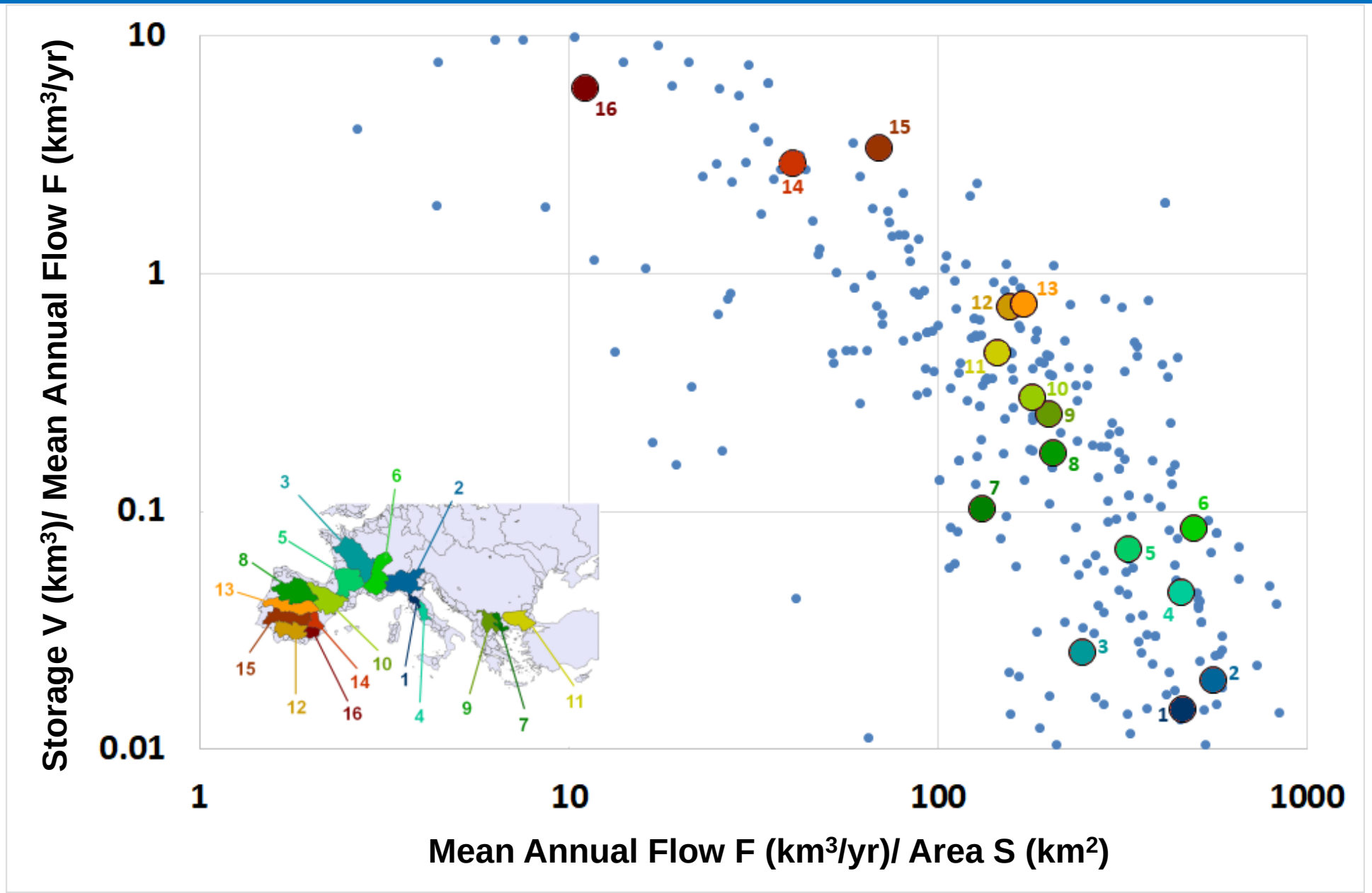
Looping over 4 emission scenarios



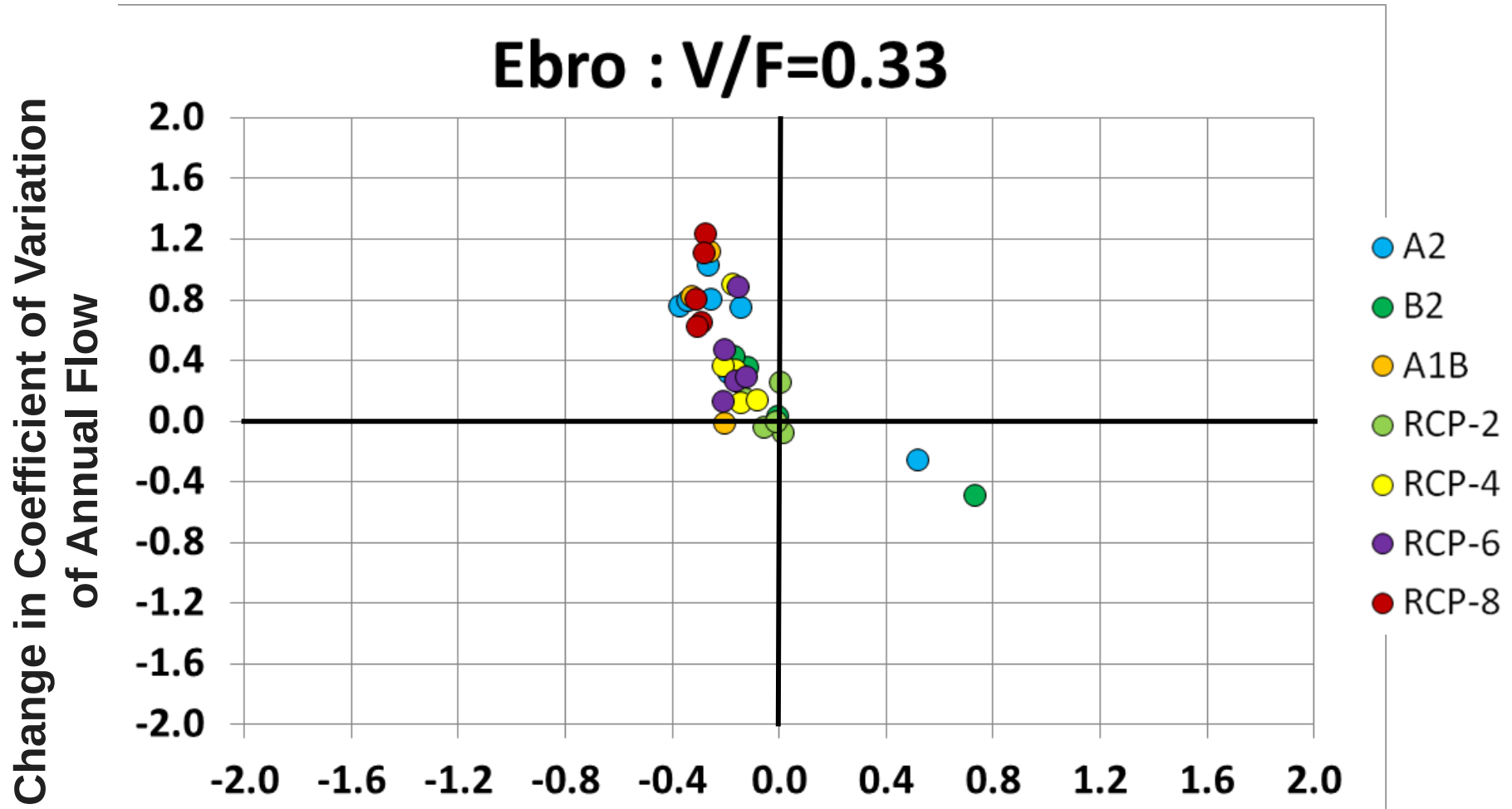




Specific study of Mediterranean basins



Climate projections



$$\Delta CV = \frac{CV_{PROJ} - CV_{HIST}}{CV_{HIST}}$$

$$\Delta MAF = \frac{MAF_{PROJ} - MAF_{HIST}}{MAF_{HIST}}$$

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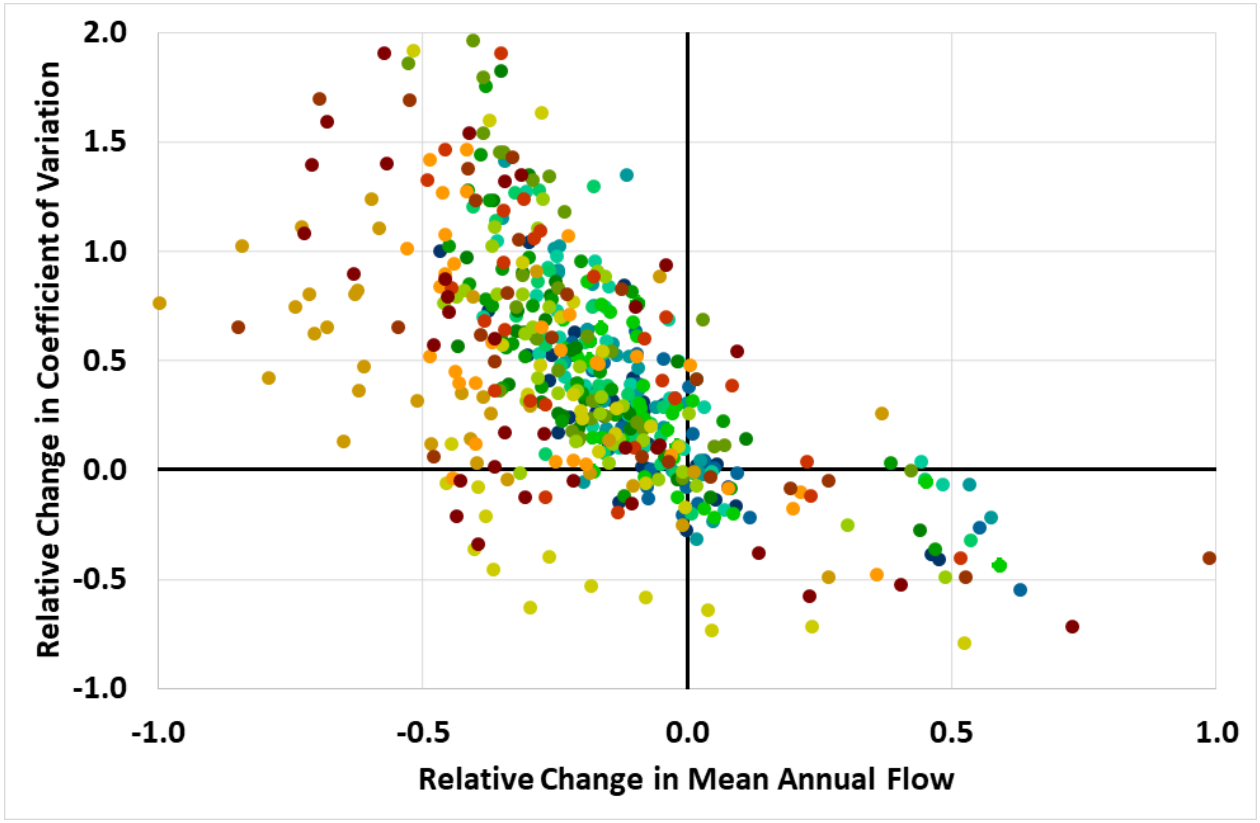
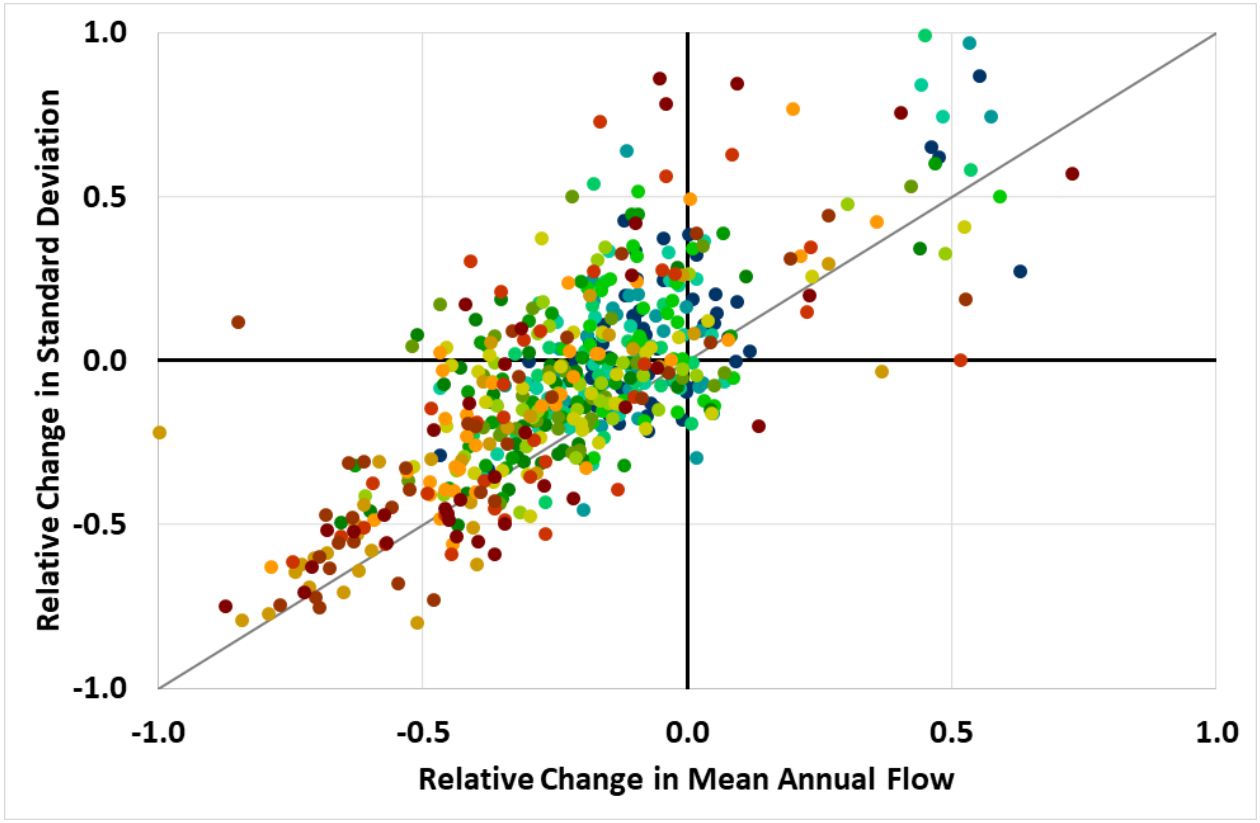
Climate projections

All emission scenarios

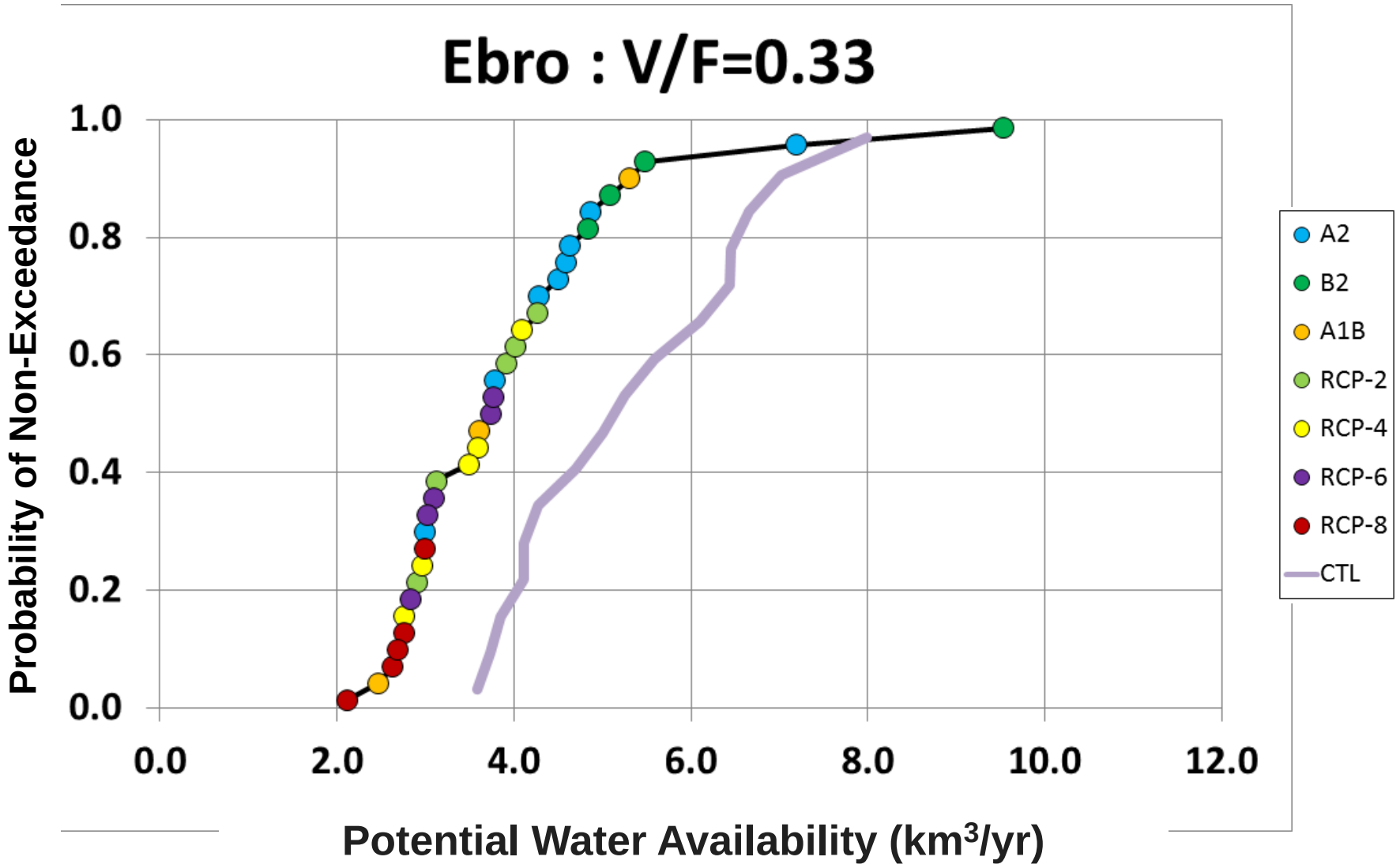




1-Arno 2-Po 3-Loire 4-Tiber 5-Garonne 6-Rhône 7-Struma-Strymon 8-Duero-Douro
9-Vardar-Axios 10-Ebro 11-Maritsa-Evros 12-Guadalquivir 13-Tajo-Tejo 14-Jucar 15-Guadiana 16-Segura

Reduction in MAF and larger increase in CV
Stronger forcing in areas already exposed to water scarcity

Potential Water Availability



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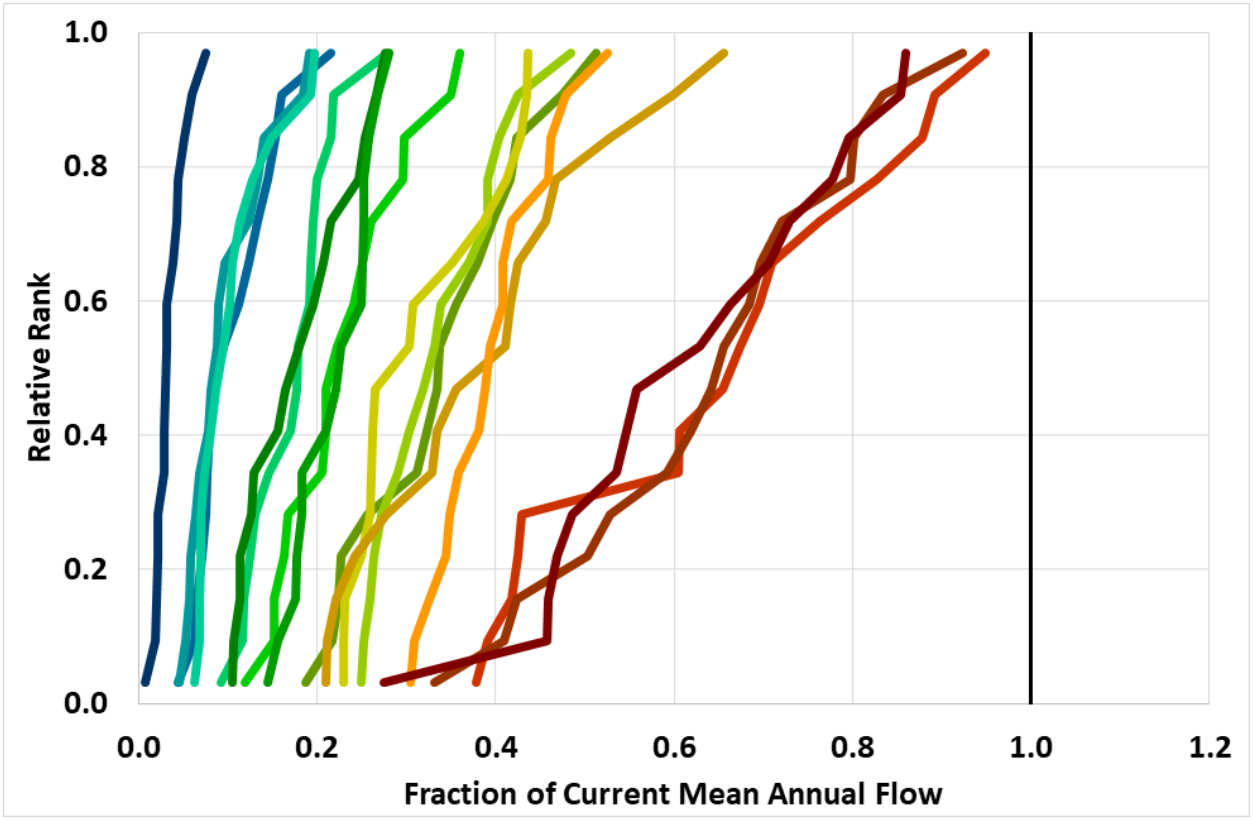
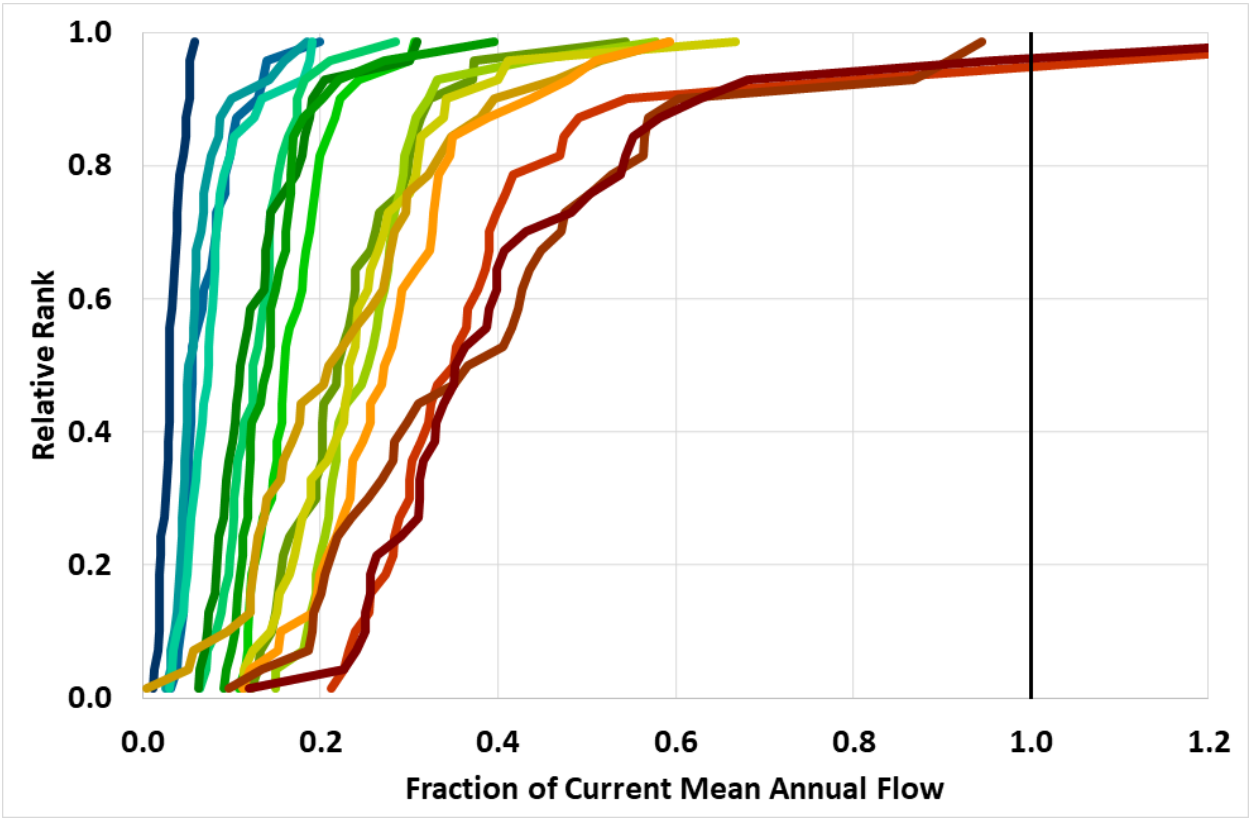
Potential water availability

Control 1960-2000



Long term 2070-2100



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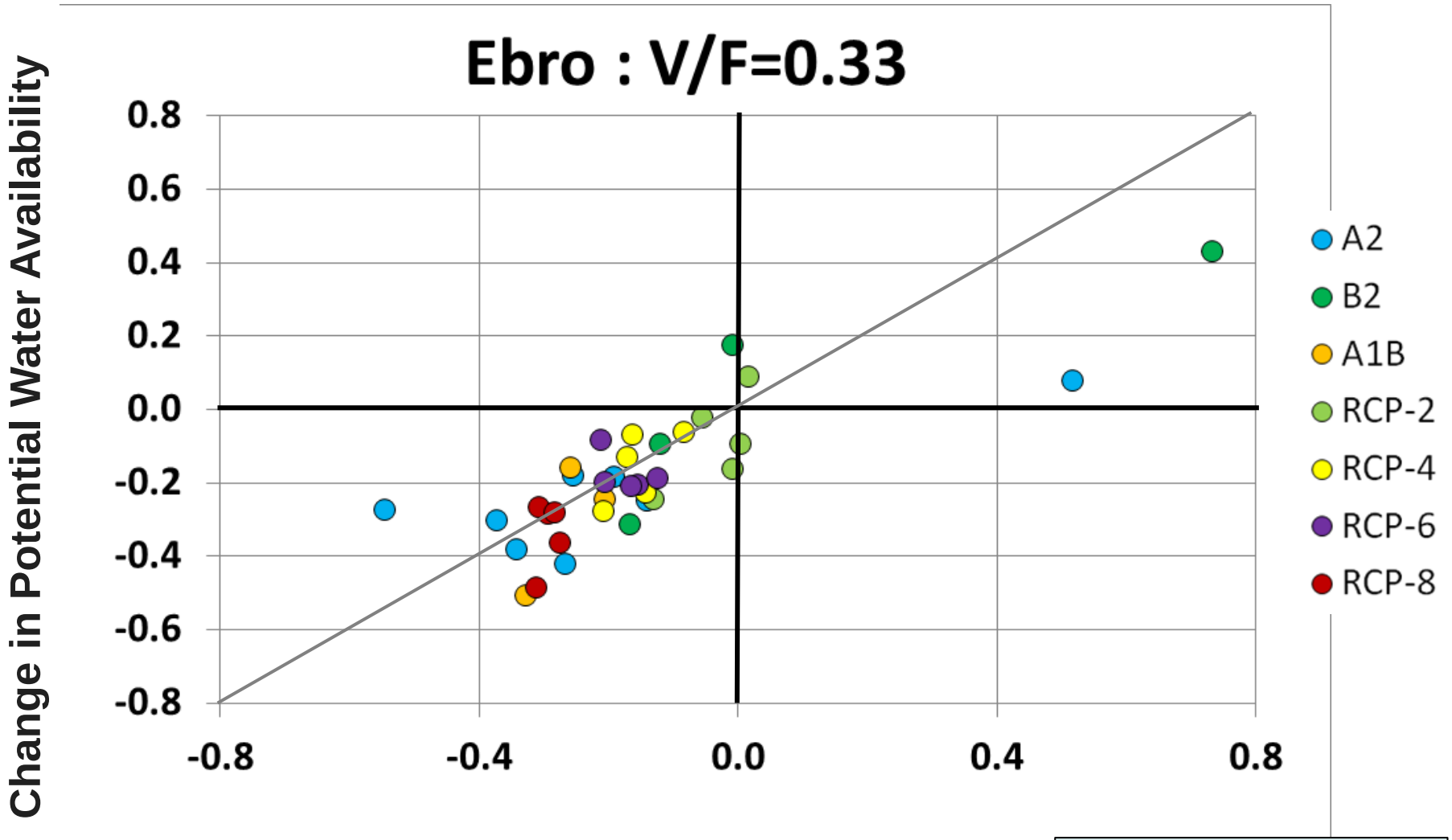
9-Vardar-Axios 10-Ebro 11-Maritsa-Evros 12-Guadalquivir 13-Tajo-Tejo 14-Jucar 15-Guadiana 16-Segura

Large uncertainty and significant reduction of PWA
Storage contributes to determine water availability

Projected changes of MAF vs. PWA

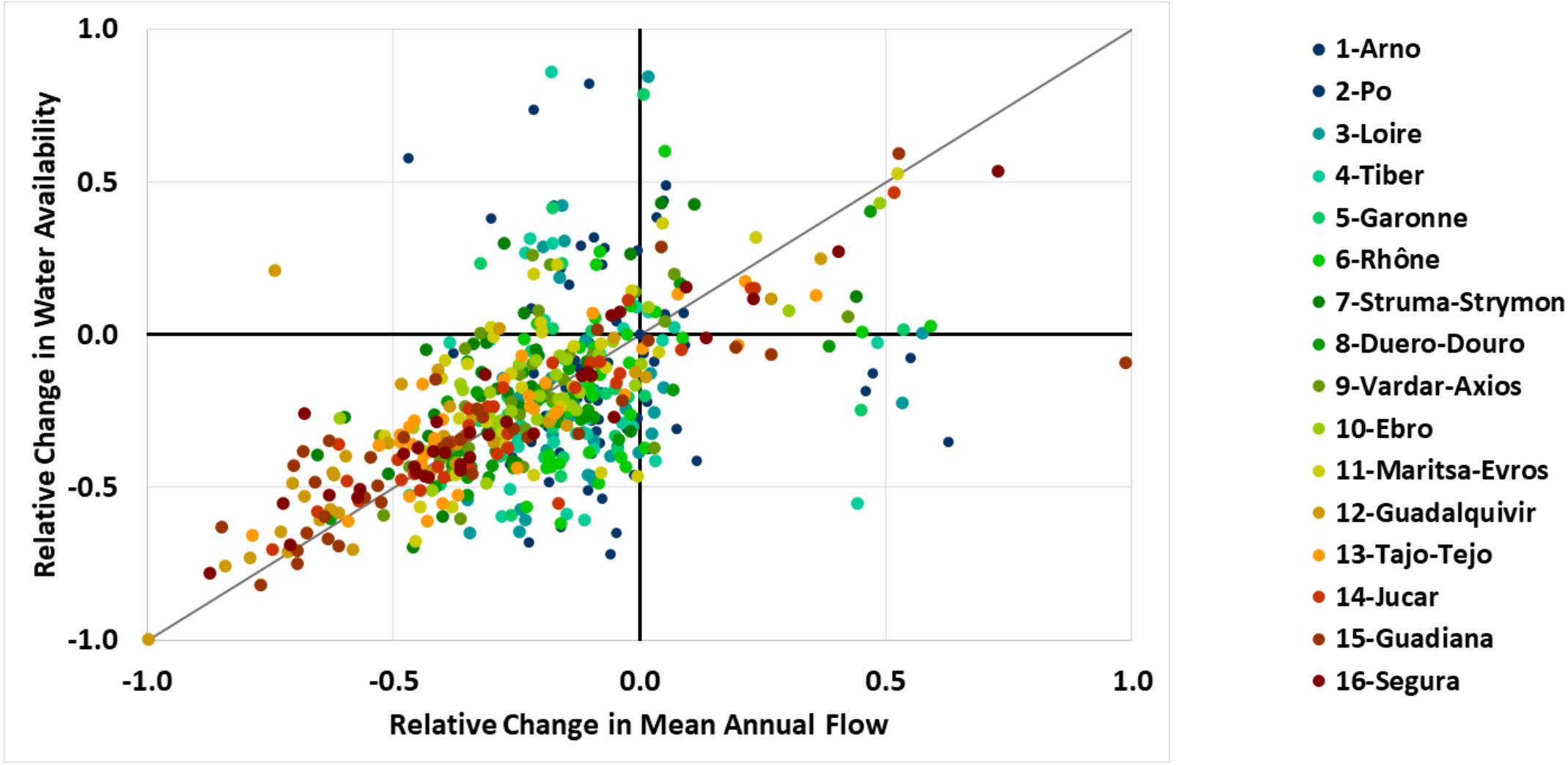


$$\Delta PWA = \frac{PWA_{PROJ} - PWA_{HIST}}{PWA_{HIST}}$$

$$\Delta MAF = \frac{MAF_{PROJ} - MAF_{HIST}}{MAF_{HIST}}$$

Projected changes of MAF vs. PWA

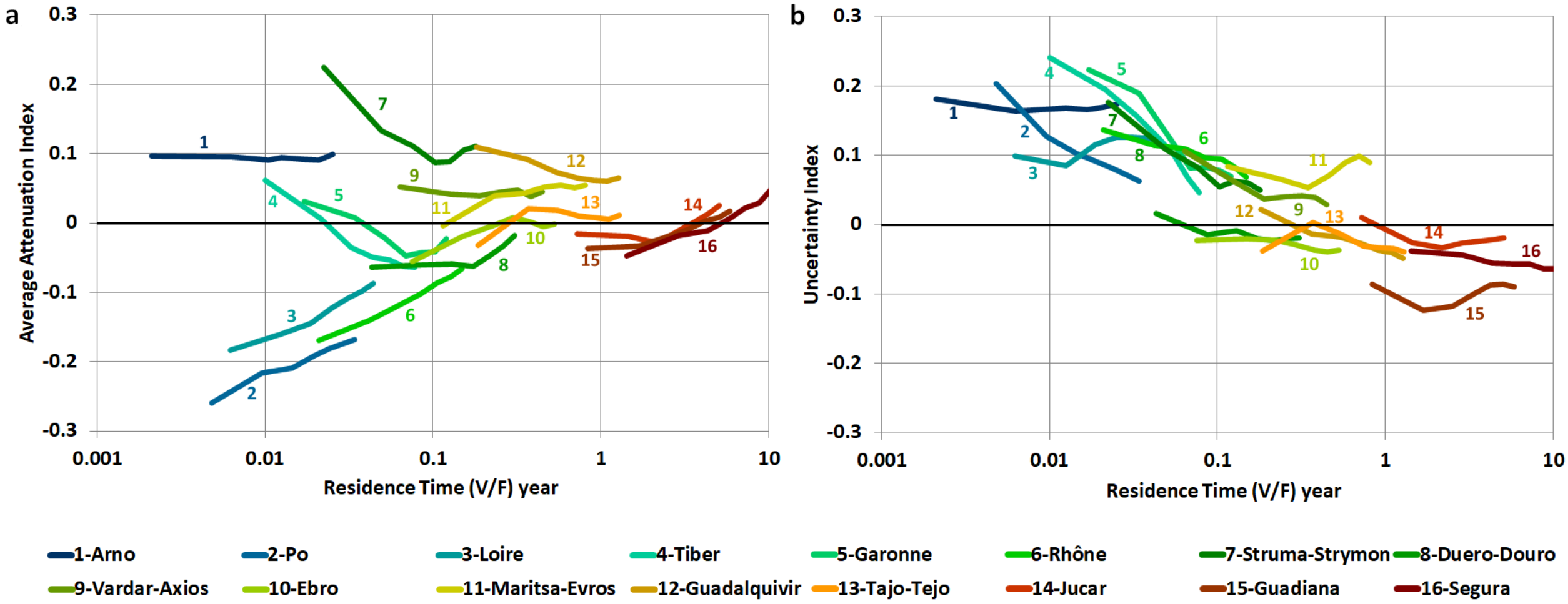
All emission scenarios



Changes in MAF are a good proxy for changes in PWA
We found stronger dispersion in areas with high variability

The role of reservoir storage

Sensitivity analysis to reservoir storage



Reservoir storage can attenuate the effects of runoff change and reduce uncertainty

The role of adaptation

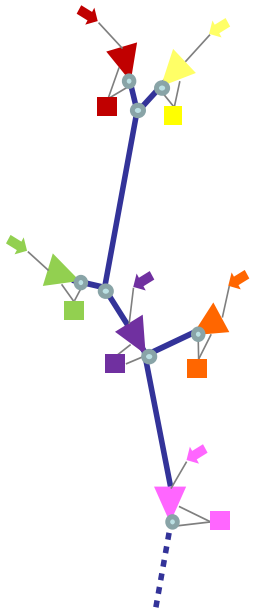
- **Strong reductions of runoff and water availability**

- **Policy and management may modify availability**
  - Water allocation to environmental flows
  - Investment in infrastructure or improved management
  - Governance: social arrangements to accept less reliability

- **What is the impact of policy on water availability?**
  - Simple analysis based on modelling framework

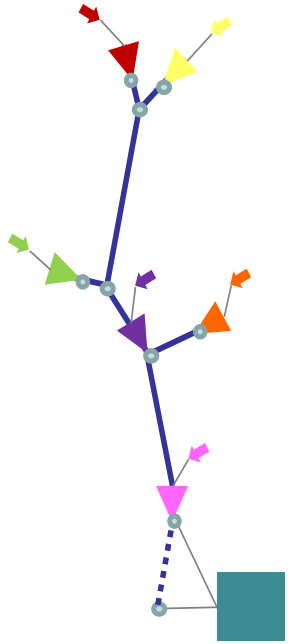
Adaptation options

Reference Management



Every reservoir supplies local demands only

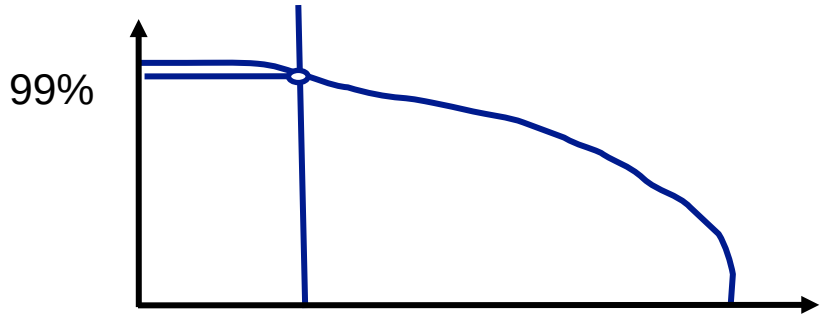
Improved Management



All reservoirs contribute to supply all demands

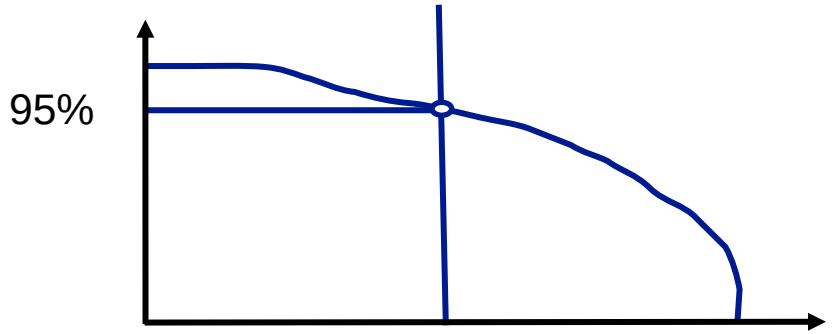
POLICY: densification of water transport and distribution networks; enhancement of management capacity

Reference Governance



Water users do not share resources

Improved Governance



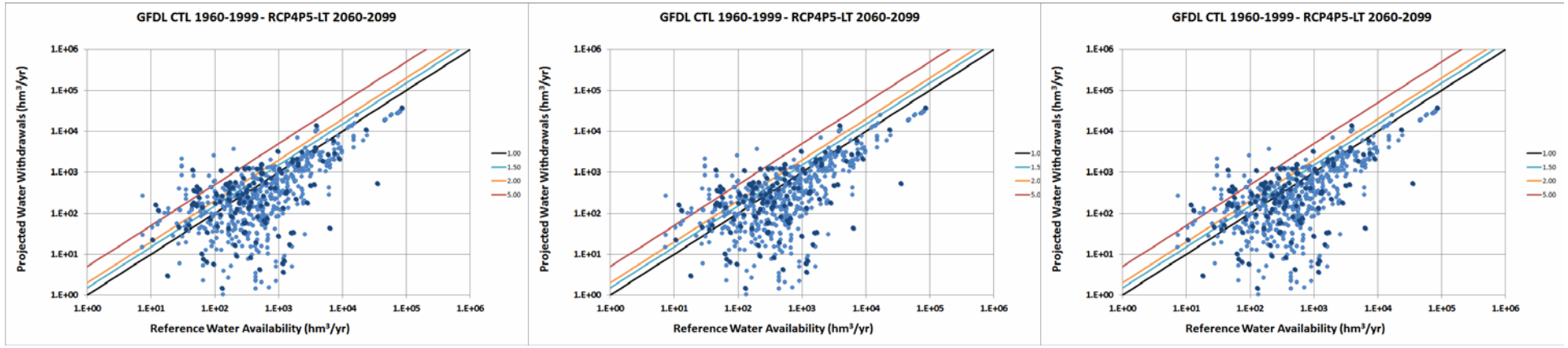
Water users cooperate and share resources

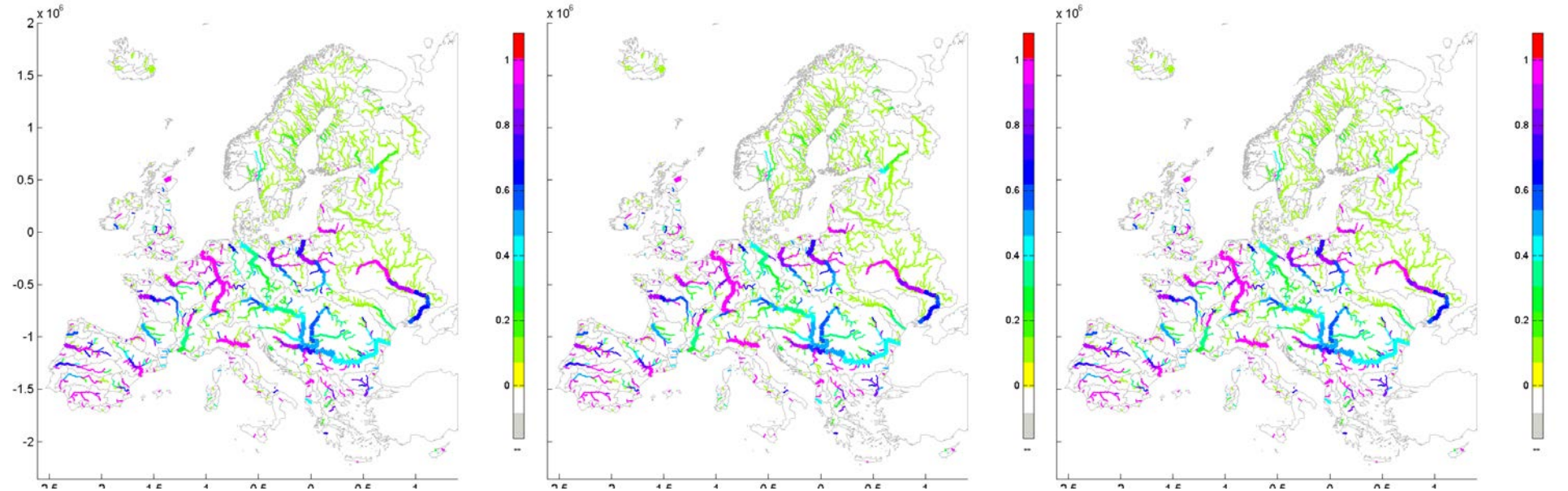
POLICY: enhancement of legal framework for water sharing; capacity building to improve education of water users

Effect of adaptation: management and governance

GFDL MODEL RCP4.5 LONG TERM 2060-2099 WITHDRAWAL/AVALABILITY

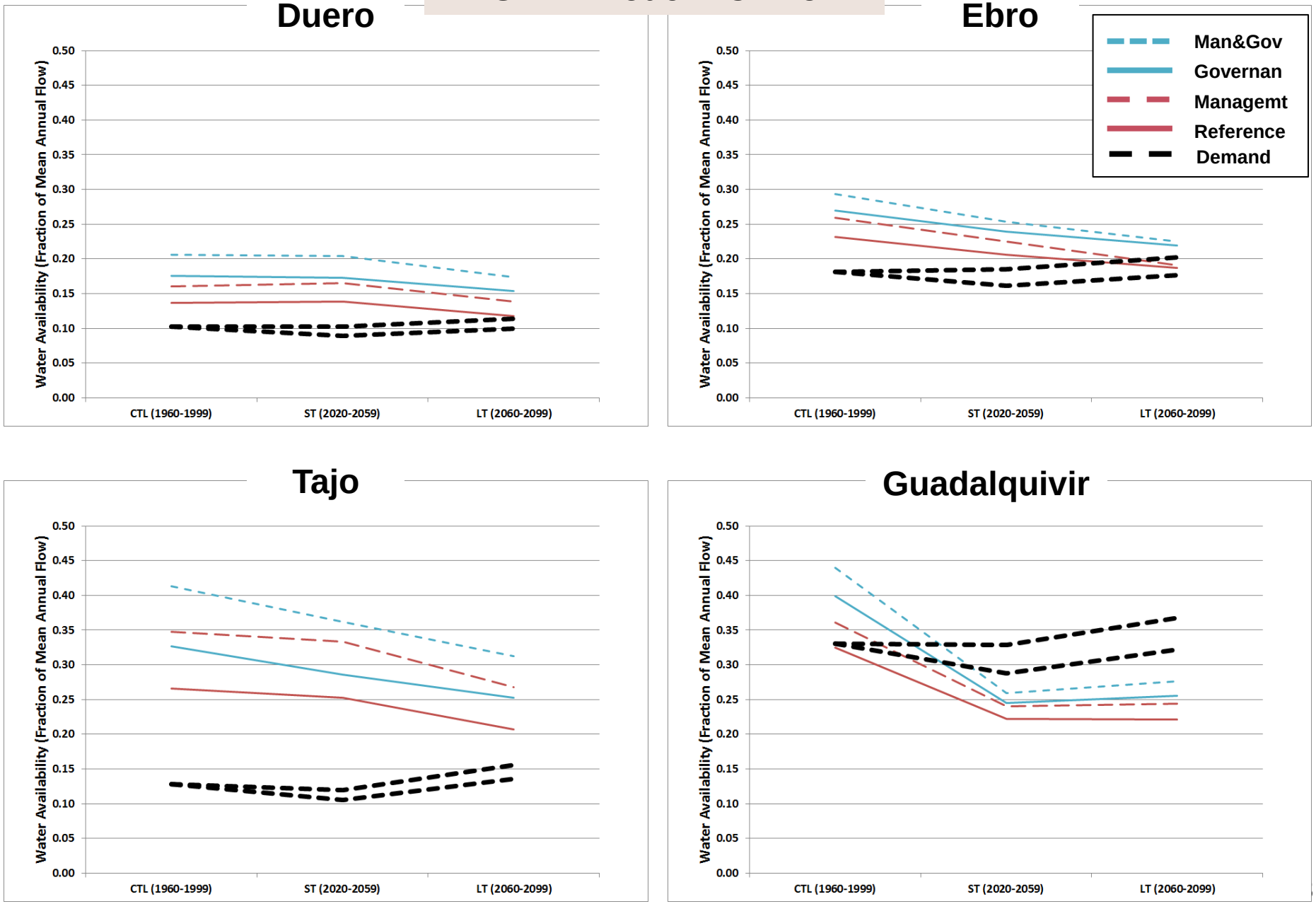
IMPROVED MANAGEMENT | **IMPROVED GOVERNANCE** | **IMPROVED MAN&GOV**





Effect of adaptation: management and governance

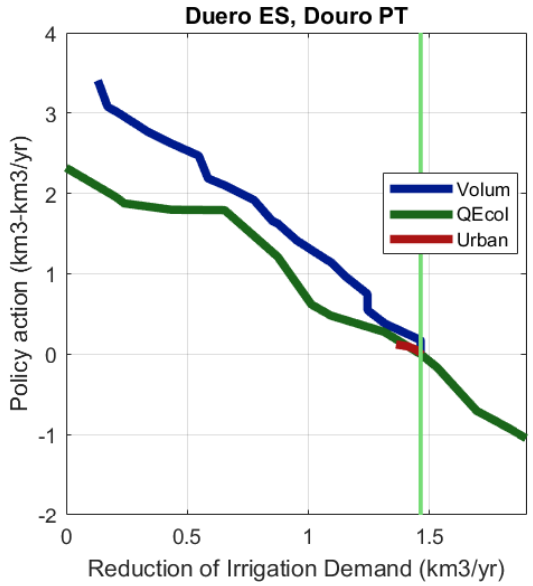
GDFL model RCP4.5

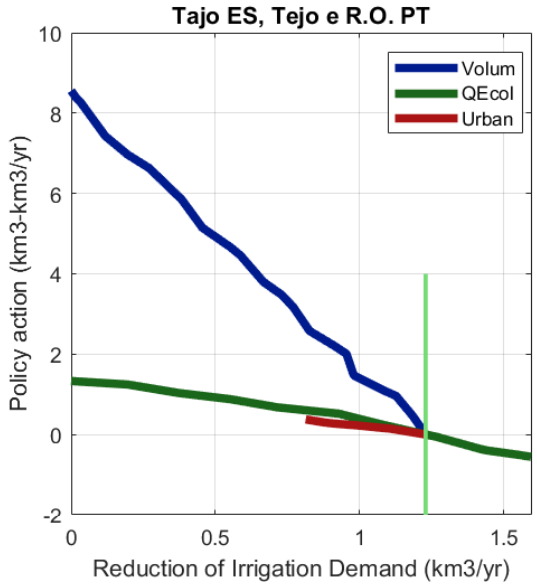


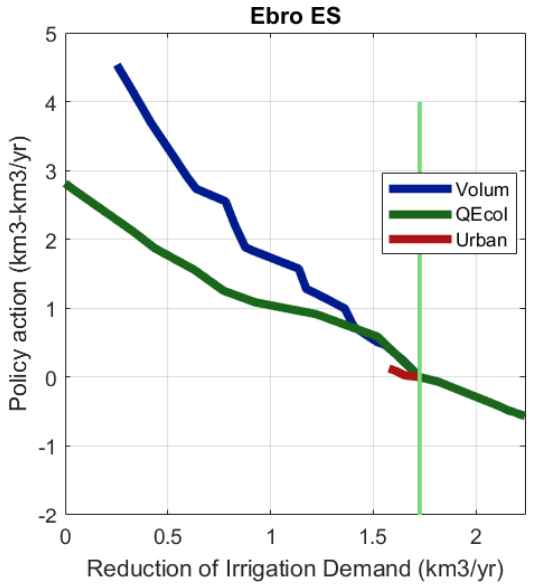
Effect of adaptation: Storage, Environmental Flow, Efficiency

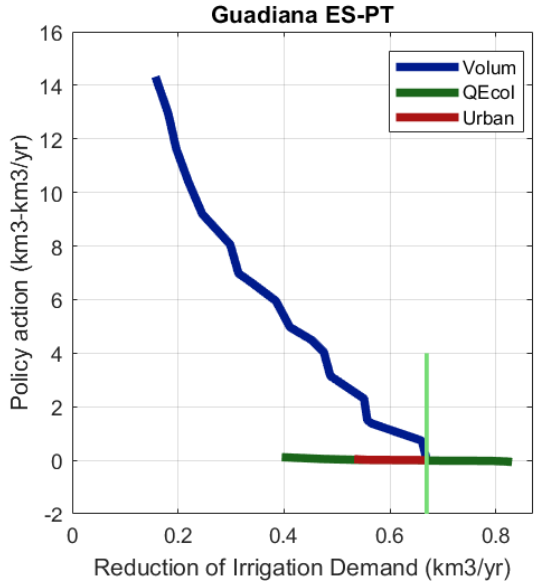
- **Policy target**
  - Maintain acceptable reliability under climate change scenarios
- **Main policy action**
  - Demand reduction to maintain reliability under climate change
- **Additional policy actions**
  - Supply enhancement through increased reservoir storage
  - Increase water efficiency in urban use
  - Modify environmental flow conditions

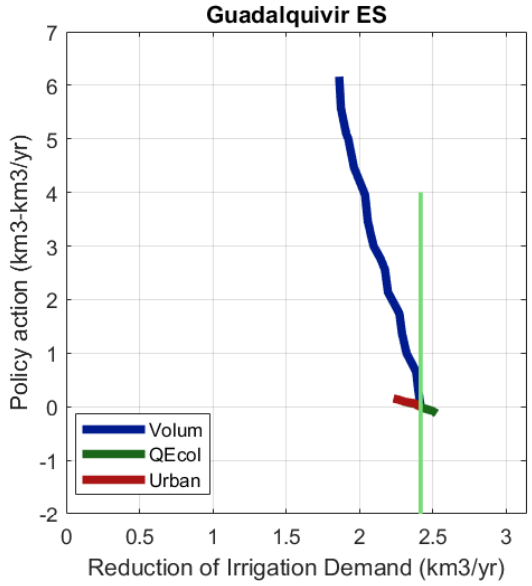
Effect of adaptation: Storage, Environmental Flow, Efficiency

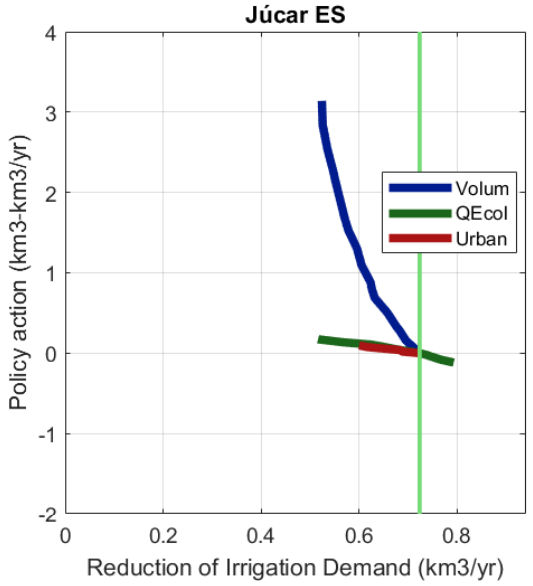












Conclusions

- **Modeling tools**
  - Care should be taken while estimating changes in water availability
  - Model uncertainty is very wide, equal or greater than emission scenario uncertainty. Is this of any use?

- **Water availability projections**
  - Climate change impacts on water availability are uncertain and heterogeneous, but are expected to be strongly negative in Southern Europe
  - Impacts are stronger in areas already affected by water scarcity

- **Role of adaptation policy**
  - Improved water management and water governance may compensate adverse effects of climate on water availability
  - Effectiveness varies across basins, requiring local analyses

Further reading from Water Journal

A Continental Assessment of Reservoir Storage and Water Availability in South America

by Bolivar Paredes-Beltran, Alvaro Sordo-Ward, B. de-Lama and Luis Garrote
Water **2021**, *13*(14), 1992; **https://doi.org/10.3390/w13141992** - 20 Jul 2021
Viewed by 657

Exploring the Role of Reservoir Storage in Enhancing Resilience to Climate Change in Southern Europe

by Alfredo Granados, Alvaro Sordo-Ward, Bolívar Paredes-Beltrán and Luis Garrote
Water **2021**, *13*(1), 85; **https://doi.org/10.3390/w13010085** - 01 Jan 2021
Cited by 2 | Viewed by 765

Adaptation Effort and Performance of Water Management Strategies to Face Climate Change Impacts in Six Representative Basins of Southern Europe

by Alvaro Sordo-Ward, Alfredo Granados, Ana Iglesias, Luis Garrote and María Dolores Bejarano
Water **2019**, *11*(5), 1078; **https://doi.org/10.3390/w11051078** - 23 May 2019
Cited by 11 | Viewed by 1542

Blue Water in Europe: Estimates of Current and Future Availability and Analysis of Uncertainty

by Alvaro Sordo-Ward, Isabel Granados, Ana Iglesias and Luis Garrote
Water **2019**, *11*(3), 420; **https://doi.org/10.3390/w11030420** - 26 Feb 2019
Cited by 11 | Viewed by 1229